MODELS OF EQUILIBRIUM REAL EXCHANGE RATES REVISITED:
A SELECTIVE REVIEW OF THE LITERATURE

by

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Abstract

One of the more important concepts in open macroeconomics is the "equilibrium real exchange rate" (ERER). Real exchange rate misalignments are argued to have been the cause of loss of competitiveness and growth slowdowns and eventual currency crises (in the event of sustained overvaluations), overheating (in the event of sustained undervaluation), sectoral misallocation of resources, and global macroeconomic imbalances. This paper examines the underlying concepts, assumptions and analytical bases of commonly employed models of the equilibrium real exchange rate and the manner in which they are usually computed (i.e. operationalized) as well as their shortcomings.

1.   Introduction

One of the more important concepts in open macroeconomics is the "equilibrium real exchange rate" (ERER). While real exchange rates are mean reverting in the long run, there is ample evidence to suggest that there can be quite significant and persistent deviations from the ERER in the short and medium terms (i.e. real exchange rate misalignments). Such real exchange rate misalignments are argued to have been the cause of loss of competitiveness, growth slowdowns and eventual currency crises (in the event of sustained overvaluations), overheating (in the event of sustained undervaluation), sectoral misallocation of resources (between tradables and nontradables), and even global macroeconomic imbalances (i.e. undervaluation of many Asian currencies and the Chinese currency in particular).[1] In view of the key role played by the ERER in economic growth, development and stabilization, monetary authorities, particularly those in small and open economies, pay close attention to movements in the real exchange rate either directly or via the monetary conditions index (MCI).[2]

Despite the repercussions that misalignments from the ERER can have on the rest of the economy it remains a rather illusive and ill-defined concept. This paper offers an analytical overview of *selected* models and definitions of ERER and explores two interrelated questions: (a) what are the economic fundamentals that go into estimating the ERER? and (b) what are the main differences between the models? The remainder of this paper is organized as follows. Section 2 presents some basic definitions of the real exchange rate, its decomposition into tradables and non-tradables, and its links to

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[1] For instance, see Edwards (1989). Harberger (2004) notes "the real exchange rate occupies a very important role – it is the principal equilibrating variable of a country's international trade and payments."

[2] The MCI is the weighted average of the deviation of the real exchange rate from its equilibrium (or base) level and the deviation of the real interest rate from its base level. In general the smaller and more open the economy the greater the weight placed on the exchange rate term in view of its impact on domestic inflation via pass-through. See Rajan (2006) for a recent discussion of the MCI in the context of monetary and exchange rate policies in small and open economies in emerging Asia.

Purchasing Power Parity (PPP). While the PPP remains the most used and simplest form of ERER, its limitations are well documented. These drawbacks of the PPP have motivated economists to search for alternative models of ERER to aid policy analysis. Section 3 introduces the "Fundamental Equilibrium exchange rate" (FEER) real exchange rate which is probably the best known of the non-PPP based model of ERER. It would be fair to say that the other ERER models have developed in response to particular weaknesses of the FEER. Section 4 concentrates on the concepts of the "Behavioral Equilibrium exchange rate" (BEER) and its close cousin the "Permanent Equilibrium exchange rate" (PEER). Section 5 turns its attention to the concept of the Natural Rate of Exchange (NATREX) which introduces dynamics in the determination of the ERER. The final section offers some concluding remarks with particular reference to China.

2.   Real Exchange Rate: Measurement and Definition

Before one can discuss models of ERER it is important to clarify the basic definition of the real exchange rate (Q). At the simplest level the real exchange rate is given as follows:

$$Q = \frac{E.P*}{P} \qquad (1)$$

where: (P) and (P^*) are the domestic and foreign price levels, respectively and (E) is the nominal exchange rate expressed as units of domestic currencies per unit of foreign currency. Hence a rise in (E) and (Q) implies a depreciation of nominal and real exchange rate of the local currency, respectively.

In the logarithm forms, both domestic price (p) and foreign price $(p*)$ can be expressed in the following manner: [3]

$$p = \beta.p^{NT} + (1-\beta).p^{T} \tag{2a}$$

$$p^{*} = \beta^{*}.p^{*NT} + (1-\beta^{*}).p^{*T} \tag{2b}$$

where: $\left(p^{NT}\right)$ and $\left(p^{*NT}\right)$ are domestic and foreign non-tradable prices, respectively and $\left(p^{T}\right)$ and $\left(p^{*T}\right)$ are domestic and foreign tradable price, respectively. (β) and $(1-\beta)$ are the shares of non-tradable and tradable sectors for the domestic economy, while (β^{*}) and $(1-\beta^{*})$ are the corresponding shares for the foreign economy.

Substituting Equations (2a and 2b) into Equation (1) we can redefine the real exchange rate (q) as:

$$q = \left(e + p^{*T} - p^{T}\right) - \left((1-\beta)\left(p^{NT} - p^{T}\right) - (1-\beta^{*})\left(p^{*NT} - p^{*T}\right)\right) \tag{3}$$

Equation 3 suggests that the fluctuations of real exchange rate movements are potentially driven by two different sources, viz. the real exchange rate of tradable goods $\left(e + p^{*T} - p^{T}\right)$, and the ratio of the domestic to the foreign relative prices of non-tradable and tradable goods $\left((1-\beta)\left(p^{NT} - p^{T}\right) - (1-\beta^{*})\left(p^{*NT} - p^{*T}\right)\right)$.[4] Of course, if Purchasing Power Parity (PPP) in the tradables sector holds then the first term in equation 3 is zero,

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[3] Note that small letters refer to logarithms hereafter.

[4] Also see Harberger (2004).

implying that the real exchange rate is determined solely by the relative gaps in non-tradables and tradables prices domestically vis-à-vis the country's trading partners.[5]

Equation (3) is highly versatile and explains why many a times there are different interpretations and uses of the real exchange rate. For instance, if PPP in the tradables sector does not hold and one is only interested in examining the movements of real exchange rate driven by the tradable sector of the economy, then the use of unit value of export indices (or producer price indices (PPI)) may be more appropriate. In relation to this, movements in the real exchange rate have also often been used to measure the relative competitiveness of an economy. In this case the relative prices are often proxied by unit labor costs (ULCs) to focus on the cost competitiveness of the economy.[6] In some cases (especially in the context of a very small economy), if one assume $\left(p^{*NT} - p^{*T} \right)$ = 0, then the real exchange rate is a measure of relative domestic prices of nontradables to tradables and is sometimes proxied as CPI divided by WPI.[7] In this case the real exchange rate is purely a measure of sectoral resource allocation as opposed to "competitiveness" per se.

More generally, Equation (3) emphasizes that the movements of real exchange at any point in time can be driven by changes in prices that occur in both the non-tradable and tradable sectors in the domestic country and those in its trading partners, as well as changes in the structures of the two economies (i.e. β and β^*). Understanding the structure of the economy and the weights assigned to various sectors

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[5] The share of non-tradable sector has been found to be significant among the transition and developing economies (Egert, et al., 2006).

[6] Harberger (2004) is critical of such an interpretation of the real exchange rate.

[7] For instance, Edwards (1989) defines the ERER as the "relative price of tradable to nontradables that, for a given sustainable (equilibrium) values of other relevant variables – such as taxes, international prices, and technology – results in the simultaneous attainment of internal and external equilibrium" (p.16).

of the economy should therefore be a prerequisite to generate comprehensive analyses of the sources of exchange rate movements and the forces driving the equilibrium exchange rate.

3. The Fundamental Equilibrium Exchange Rate (FEER)

3.1 Underlying Theoretical Concepts

Recognizing the limitations of PPP (for instance, see Driver and Westaway, 2004 and Rogoff, 1996), a great deal of attention has focused on determining alternative measures of ERER based on some fundamental exchange rate determinants. One of the most widely used measures -- largely credited to Williamson (1994) -- is the concept of fundamental equilibrium exchange rate (FEER), Williamson (1994) defines FEER as a real effective exchange rate that simultaneously ensures internal and external balances. Internal balance is said to be reached when the economy is at full employment output and operating in a low inflation environment. With regard to external balance ,the FEER approach abstracts from the short-run cyclical and speculative forces in the foreign exchange market and focuses on factors that are expected to persist over the medium-term horizon. More precisely, external balance is characterized as a sustainable balance of payment position over a medium-term horizon, ensuring desired net flows of resources and external debt sustainability. A minimum criterion for external balance is that the current account balance be "sustainable" over time.

Unlike the simple PPP approach, the FEER approach recognizes that the ERER will vary across time as factors impacting sustainable internal and external balances evolve. In the case of internal balance, for instance, apart from potential output growth associated with low inflation both in domestic and foreign economies, potential differences in the productivity growth between tradables and nontradables sectors in an

economy could lead to a depreciation or appreciation of the FEER.[8] Similarly, the notion of "sustainable" current account level could change over times.

The operationalization of the FEER usually involves two sequential steps (Clark and MacDonald, 1998 and MacDonald, 2000). First is to identify the external balance equation by simply equating current account balance (CA) to capital account balance (KA).

$$CA = -KA \tag{4}$$

The current account is a sum of net trade balance and returns on net foreign assets $(nfar)$. The net trade balance (ntb) is assumed to be a function of the real effective exchange rate and full employment output of the local and foreign economies, i.e. $(\bar{y}_d)$ and $(\bar{y}_f)$ respectively. The returns on net foreign asset are also influenced by the movements of the exchange rate, i.e. real exchange rate (q) depreciation raises the domestic currency returns on foreign assets. Key relationships for the FEER approach can therefore be encapsulated in the following equations.

$$CA = ntb + nfar \tag{5a}$$

$$ntb = \delta_0 + \delta_1 q + \delta_2 \bar{y}_d + \delta_3 \bar{y}_f \tag{5b}$$

where: $\delta_1 > 0, \ \delta_3 > 0,$ and $\delta_2 < 0.$

$$nfar = f(q) \tag{5c}$$

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[8] While the Balassa-Samuelson effects comes to mind immediately, there is reason to believe that trend real exchange rate appreciation for fast growing economies may not always hold. For instance, see Miyajima (2005).

In most applications of the FEER approach the level of equilibrium capital account over the medium term $(\overline{KA})$ is exogenously determined. Combining Equations (4 and 5a-5c) and the basic assumptions discussed above derives the following medium-term balance of payment equation:

$$CA = f\left(q^{FEER}, \overline{y}_d, \overline{y}_f\right) = -\overline{KA} \tag{6}$$

Given full employment output of the local and foreign economies, $(\overline{y}_d)$ and $(\overline{y}_f)$ respectively, and that of medium-term equilibrium $(\overline{KA})$, the last step is to solve Equation (6) for (q^{FEER}).

$$q^{FEER} = f\left(\overline{KA}; \overline{y}_d; \overline{y}_f\right) \tag{7}$$

3.2   Critical Analysis of the FEER

The FEER is considered a normative measure of equilibrium exchange rate as it is the rate consistent with some notion of "ideal" economic circumstances of internal and external balances. While the definition of internal balance is somewhat less controversial, the assumption of sustainable current account as a measure of external balance has been criticized for being too subjective in nature. For instance, in the applications of the FEER, the medium-term current account is often assumed to be at the level commonly accepted as the desirable rate (1 percent in the case of the US).[9] It

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[9] The one percentage of GDP current account surplus target was chosen as it was the stated objective of the US Administration during the Smithsonian discussion of appropriate parities for the exchange rates for the major industrial countries (see Bayoumi et.al., 1994).

has therefore been suggested that the equilibrium real effective exchange rate derived from the FEER approach (to be called "desired equilibrium exchange rate" or DEER).

The normative position on the current account has also been criticized for imposing "an extra layer of judgment … when calculating trade elasticity" (MacDonald, 2000). Considering a simplest form of current account (Equation 5a), where the $(nfar)$ component is assumed to be zero or relatively small when compared to (ntb), real exchange rate elasticity on imports must therefore be close to the real exchange rate elasticity on exports under the assumption of "external balance". In another words, the estimated trade elasticity of the FEER is effectively close to zero (Goldstein and Khan, 1985 and Wren-Lewis, 1992). Relying too much on the trade elasticity may generate an inaccurate estimate of the FEER trajectory. A depreciation of real exchange rate of the domestic currency would not only lead to an improvement in (ntb) but should also should increase $(nfar)$. If the FEER only captures the changes in (ntb) and assume the impact on $(nfar)$ to be exogenously determined, then the size of the required real exchange rate appreciation may be overestimated.[10] Hence the size of currency misalignment estimated by FEER is likely to be inaccurate one.

Bayoumi, et al. (1994) and Driver and Westaway (2004) further highlight the analytical limitation introduced into the FEER due to possible fluctuations on the returns of net foreign asset. MacDonald (2000) highlights this point most clearly and we quote him at length:

> (A)ssume that in the initial period the current exchange is at the FEER level and internal and external balances obtain. The actual exchange rate then depreciates in the next period, thereby improving the current balance and improving the net foreign asset position. The latter, in turn, implies that in future periods the real exchange rate which is consistent with

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[10] Obstfeld and Rogoff (1995) show a simple correlation between changes in the real exchange rates and changes in the net foreign asset position (though we note the usual caveat that correlation does not imply causation).

medium-run capital accumulation will no longer be the FEER; in particular, the FEER needs to appreciate to squeeze out the effects of net accumulation. This hysterisis effect is a necessary consequence of viewing the exchange rate as a medium run concept" (p.39).[11]

4. The Behavioral and Permanent Equilibrium Exchange Rate (BEER and PEER)

The Behavioral Equilibrium exchange rate (BEER) approach modifies the FEER approach by focusing on the actual and not necessarily the medium-term equilibrium values of the fundamental determinants (i.e. internal and external balance proxies) of the real exchange rate. Hence, the underlying assumption of macroeconomic balance of the FEER approach is noticeably absent under the BEER approach. We illustrate below the general framework of the BEER approach (Clark and MacDonald, 1998, 2000).

4.1 Underlying Theoretical Concepts

The theoretical underpinning of the BEER approach rests on the basic concept of uncovered interest rate parity (UIP):

$$E_t(e_{t+1}) - e_t = i_t - i_t^* \qquad (8)$$

where: $E_t(e_{t+1})$ represents the expected value of the nominal exchange rate in period (t) for period $(t+1)$. e_t is the nominal exchange rate at period (t), defined in terms of domestic currency per unit of foreign currency. Thus, a rise in (e) implies a depreciation of the local currency. (i_t) and (i_t^*) denote local and foreign nominal interest rates, respectively. (We introduce the risk premium terms later on).

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[11] The term "hysteresis" implies that different equilibrium values may not be independent of the dynamic adjustment paths toward them.

Subtracting the expected inflation differential from both sides of Equation (8), allows us to covert the nominal interest rate parity into the real interest parity.

$$E_t(q_{t+1}) - q_t = r_t - r_t^*$$
(9)

where: r_t =domestic real interest rate $= i_t - E_t(\Delta p_{t+1})$; r_t^* =foreign real interest rate $= i_t^* - E_t(\Delta p_{t+1}^*)$; $E_t(q_{t+1})$ denotes the expected real exchange rate at time (t) for period, and q_t is the observed real exchange rate. (p_t) and (p_t^*) are domestic and foreign price levels, respectively, at period (t). $(\Delta p_{t+1} = p_t - p_{t-1})$ and $(\Delta p_{t+1}^* = p_t^* - p_{t-1}^*)$ are the changes in domestic and foreign price level, respectively.

By rearranging Equation (9) the observed real exchange rate q_t can be represented as a function of the expected value of real exchange rate $E_t(q_{t+1})$, and the current real interest rate differential.

$$q_t = E_t(q_{t+1}) - (r_t - r_t^*)$$
(10)

Under the BEER approach the unobservable expectation of real exchange rate, $E_t(q_{t+1})$ is assumed to be determined solely by a vector of long-run economic fundamentals (Z_t). Thus, the BEER approach produces estimates of equilibrium real exchange rate (q_t^{BEER}) which incorporates both the long-run economic fundamentals $(E_t(q_{t+1}) = f(Z_t))$ and the short-run interest rate differentials.

$$q_t^{REER} = f(Z_t, (r_t - r_t^*))$$
(11)

Clark and MacDonald (1998) assumed three long-run determinants of vector (Z_t), namely terms of trade (tot), the relative price of non-traded to traded goods (tnt) and net foreign assets (nfa).

$$E_t(q_{t+1}) = f(\overline{tot}_t, \overline{tnt}_t, \overline{nfa}_t) \tag{12}$$

The signs above the right hand side variables denote the signs of partial derivatives. Clark and MacDonald (1998) also include the role of risk premium component in the uncovered interest parity (Equation 8). The time-varying risk premium is assumed to be a positive function of the ratio between domestic and foreign government debt $\left(\dfrac{gdebt_t}{gdebt_t^*}\right)$. Combining information from Equation (11), Equation (12) and the risk premium component, the BEER real exchange rate is determined by the following set of economic variables:

$$BEER = f\left((r - r^*), tot, tnt, nfa, \left(\frac{gdebt}{gdebt^*}\right)\right) \tag{13}$$

Since the equilibrium rate is not an officially observable variable, a common empirical approach to estimate the BEER involves two steps. The first step involves estimating the long-run (cointegration) relationship between the prevailing real exchange

rate and the set of short-run and long-run economic fundamentals listed in Equation (14).[12]

$$q_t = \alpha + \beta_0\left(r_t - r_t^*\right) + \beta_1 tot_t + \beta_2 tnt_t + \beta_3 nfa_t + \beta_4\left(\frac{gdebt}{gdebt^*}\right)_t \qquad (14)$$

The second step uses the coefficient parameters of each fundamental variables ($\hat{\alpha}, \hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2$ and $\hat{\beta}_4$) to compute the BEER:

$$q_t^{BEER} = \hat{\alpha} + \hat{\beta}_0\left(r_t - r_t^*\right) + \hat{\beta}_1 tot_t + \hat{\beta}_2 tnt_t + \hat{\beta}_3 nfa_t + \hat{\beta}_4\left(\frac{gdebt}{gdebt^*}\right)_t \qquad (15)$$

4.2   Comparison of FEER and BEER and Introducing the PEER

Two important observations should be noted when one compares Equation (13) of the BEER approach and Equation (7) of the FEER approach. First, unlike the FEER, the BEER approach is not a normative one. As noted, the FEER depends on somewhat abstract and subjective notions of "sustainable external balance" and "internal balance". In contrast, in the BEER, the equilibrium rate consistent with the prevailing levels of economic fundamentals.[13] Second, the BEER considers short-run cyclical/temporary factors that may contribute heavily to medium-to-long-run movements of ERER. In particular, the adoption of interest rate parity allows the BEER approach to capture the sources of changes in capital account which may then also affect the current account

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[12] Needless to say, one must initially test for stationarity of each of these variables before the cointegration test in conducted.

[13] The BEER may converge to the FEER in the medium-run under the condition where economic fundamentals driving the changes in the equilibrium exchange rate are at the full employment and sustainable levels.

and the "behavior" of the exchange rate. In contrast, the FEER approach only captures the behavior of the exchange rate driven by changes in the positions of external and internal balances.

As indicated above, the BEER is derived based on the prevailing levels of economic fundamentals. Hence, the misalignment rate (i.e. actual rate minus BEER) is often referred to as *current* misalignment rate. For policy makers it is relevant to understand whether the misalignment has largely been driven by temporary shocks or more permanent ones. Accordingly, following Clark and MacDonald (2000), many studies decompose the fundamentals into a transitory and permanent component and use the permanent components to estimate the so-called Permanent Equilibrium Real Exchange Rate (PEER). Equation 13 of the BEER can easily be modified to capture the PEER (note the ' p ' superscript denotes a permanent component):

$$PEER = f\left((r-r*)^p, tot^p, tnt^p, nfa^p, \left(\frac{gdebt}{gdebt^*} \right)^p \right) \qquad \textbf{(16)}$$

Techniques introduced by Beveridge and Nelson (1981), Clarida and Gali (1995), Stock and Watson (1998) and Gonzalo and Granger (1995) are some of the commonly used empirical tools to decompose the non-stationary series into permanent (the non-stationary part) and the temporary (stationary) component. The misalignment rate (i.e. actual rate minus PEER) is often referred to as *total* misalignment rate.

5.   The Natural Rate of Exchange (NATREX)

While the BEER/PEER approaches are important extensions of the FEER, these models do not capture the nature of the convergence process from the short-run/actual

rate to the equilibrium rate, i.e. (MacDonald, 2000). Partly in response to this, Stein (1994) developed the "Natural Rate of exchange" or NATREX defined broadly as the rate that would prevail if speculative and cyclical factors could be removed while unemployment is at its natural rate. Stein (2001) has offered the clearest definition of the NATREX-based view of the ERER:

> The equilibrium value of the real exchange rate is a sustainable rate that satisfies several criteria. First; it is consistent with internal balance. This is a situation where the rate of capacity utilization is at its longer run stationary mean. Second, it is consistent with external balance. The latter is a situation where, at the given exchange rate, investors are indifferent between holding domestic or foreign assets. At the equilibrium real exchange rate, there is no reason for the exchange rate to appreciate or depreciate. Hence, portfolio balance or external balance implies that real interest rates between the two countries should converge to a stationary mean. As long as there are current account deficits, the foreign debt and associated interest payments rise. If the current account deficit/foreign debt exceeds the growth rate of real GDP, then the ratio of the debt/GDP and the burden of the debt - net interest payments/GDP - will rise. When the debt burden is sufficiently high, devaluation will be required to earn enough foreign exchange through the trade balance to meet the interest payments. The condition for external equilibrium in the longer run is that the ratio of the foreign debt/GDP stabilizes at a tolerable level (pp.1-2).

In this sense the NATREX is akin to FEER in that it focuses on the medium-term, though as will be seen, it also allows for the introduction of short-run dynamics. More to the point, the NATREX approach is based on two broad pillars. First, the framework of the approach lies on the national income accounting equation:

$$I - S + CA = 0 \qquad\qquad\qquad (17)$$

where: (I) is the desired investment, (S) denote the desired saving and (CA) is the desired current account. Note that the various terms are *desired* as opposed to *actual* levels (the latter would make Equation 17 an identity). Equation (17) captures the medium-run equilibrium when the economy is operating at capacity output and

expectations about inflation is met -- similar to that of the FEER approach. The levels of desired saving and investment depend on the existing stock of capital, wealth, and net debt to foreigners. The medium-run position is characterized by the following conditions: a) the domestic securities market clear; b) cyclical and short-term speculative capital flows cancel out; c) any difference between investment and saving represents the excess flow of supply of tradable long-term securities. Hence, under these conditions, Equation (17) also captures the balance of payment equilibrium (the sum of capital and current account balance).

Second, the fundamentals, denoted by vector $(Z(t))$, are disturbances to productivity and social thrift (time preference of consumption/expenditure by household and government) at home and abroad (Stein, 1994). Changes in $(Z(t))$ will affect capital formation, the rate of debt accumulation and also the interest rate. As desired saving and investment change the NATREX will fluctuate accordingly and will converge to a static long-run rate when there is no further changes in the fundamentals. Thus, unlike the other models of ERER, the NATREX is a moving equilibrium exchange rate, i.e. it adds dynamics to the determination of the ERER. The trajectory of the ERER can be decomposed into three components, viz. the medium-run, the longer-run and the steady state.

To illustrate the foregoing point more explicitly, the real exchange rate can be depicted into the three different phases/ stages. One, is the actual/spot rate: $q_t = q_t(k_t, F_t, \varepsilon_t : Z_t)$ which is the realized rate at time (t), given the stock of capital (k_t), stock of debt (F_t) and the presence of speculative capital flows. As discussed, the stocks of capital and debt are influenced by the changes in the fundamentals $(Z(t))$. Two, is the medium-run NATREX: $q = q(k_t, F_t : Z_t)$ which is affected by the changes in

the stocks of capital and debt (due to changes in the fundamentals). However, unlike the spot rate, speculative flows do not influence the medium-run NATREX. Hence, this rate is what is supposedly obtained also by the FEER approach. Three, the NATREX converges to a static long-run rate: $q^* = q^*(Z_t)$. This constant or stationary long-run real equilibrium NATREX is consistent with the PPP rate. Hence, the NATREX extends early models such as the PPP and the FEER by focusing its analyses on the periods when the fundamentals are not stationary and consequently generates the trajectories of the exchange rate from the short-term to medium-run and from the medium-run to the static long-run position. These dynamics also differentiate the NATREX from the BEER approach. As noted by Stein (2001):

> The principal difference between the BEER and the NATREX, is that the NATREX takes as its point of departure a specific theoretical dynamic stock-flow model to arrive at a reduced form where the equilibrium real exchange rate depends upon relative thrift and relative productivity differences (p.5).

Two issues often arise in estimating the NATREX. First is to do with the selection proxies for the fundamentals (shocks in the productivity and the social thrift). Second is with regard to the testing procedures, i.e. between testing a single reduced form equation and estimating structural equations. Most studies applying the NATREX estimate a single reduced form equation.[14] With regard to the proxies for fundamentals, in order to capture productivity, average labor productivity is most often used (GDP/total employment), though total factor productivity (TFP) is also used by some (Stein 2001). Regarding the social thrift variable, ideally this is proxied by changes in the total consumption (household and government) over GDP during the observation period. However, since household consumption is usually found to be stationary over a long-

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[14] See Edwards (1989), Montiel (1999) and Baffes, et al. (1999) for a discussion of the use of specifying a single equation to estimate the ERER.

term span for some countries, only the ratio of government expenditure over GDP is considered to proxy the social thrift (for instance, see Stein, 2001 and Rajan and Siregar, 2002). Beyond these two fundamentals, consistent with the previous models, it is also common to include the terms of trade as one of the fundamental variables for the small open economy, as it is exogenously determined (MacDonald, 2002, 2004 and Rajan and Siregar, 2002). Hence the basic single reduced form equation for the NATREX can easily be presented as the by the following equation:

$$NATREX = f(tot, prod, thrift) \tag{18}$$

where: (tot) is the terms of trade; $(prod)$ denotes the productivity measure; and $(thrift)$ captures the social thrift or the time-preference of the consumption/expenditure behaviour of the households and the government.

In addition to the selection of the proxies for the fundamental variables it is important to add that the selection of the fundamental factors in estimating the NATREX is also open to variation, largely influenced by the size of the economy and the development stages of the local economy. As an example, the terms-of-trade term is generally considered to be one of the fundamental variables for small open economies as it is exogenously given for this group of countries. However, for industrial countries the terms-of-trade is endogenously determined and may create estimation problems if included in the regression equation (18).[15] Furthermore, when applied to transition economies or emerging markets, the estimation results may indicate that some of the fundamental variables (or the proxies) are significant determinants of the medium-run, but not the long-run equilibrium exchange rate. For instance, a positive relationship

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[15] Stein (1999) for instance only considers social thrift and productivity of domestic and foreign countries when evaluating the equilibrium rate of the US dollar and the G-7 currencies.

between expansionary government expenditure and real exchange rate captures only the medium-run term. The rise in the aggregate demand, driven by the rise in government expenditure, will appreciate the real exchange rate in the medium-run. The strengthening of the local currency however would worsen the current account position through a possible deterioration on the net interest flows on foreign debt. In the long-run, a depreciation of local currency is needed to stabilize the net foreign assets. Accordingly, any analysis or policy discussions generated from the NATREX approach should take into account all of these empirical issues.

5. Concluding Remarks

Most economists would agree that a key element of successful economic policy strategy for stable growth and development is the need to ensure the real exchange rate is maintained at its "equilibrium level". Large and persistent misalignments can have significant negative economic impacts, including an eventual currency crisis (Frankel and Rose, 1996 and Kaminsky and Reinhart, 1999). This paper has examined underlying concepts, assumptions and analytical bases of commonly employed models of the equilibrium real exchange rate and the manner in which they are usually computed (i.e. operationalized) as well as their shortcomings. Clearly there is no single definitive model; each has its strengths and weaknesses and results could vary depending on the model used.

As an example, Table 1 below highlights the range of estimates of degree of misalignment of the Chinese currency which is at the centre of the current debate of global macroeconomic imbalances. The basic issue of concern in the context of global macroeconomic imbalances is whether the Chinese currency is undervalued and if so, by how much (i.e. does China have an "unfair" export advantage)? As is apparent, various methodologies lead to quite different results, ranging from gross undervaluation

to more or less no misalignment. It would clearly be fallacious and hazardous to draw policy conclusions by using estimates from any single model. However if one looks at the broad average of estimates across all studies in Table 1, it appears the Chinese currency has been undervalued by between 30 and 40 percent vis-à-vis the US dollar and between 15 and 20 percent on a real trade-weighted basis. This example emphasizes the importance of considering a number of alternative equilibrium real exchange rate models in order to come up with a range of estimates of misalignment before one draws any firm policy conclusion.

Table 1: Alternative Estimates of Misalignment of the Chinese Real Exchange Rate[1]

Author/Study	Method	Type of Exchange Rate	Period	Misalignment[2]
Bénassy-Quéré et al. (2004)	BEER	Dollar	2003	-47%, -44%
Coudert and Couharde (2005)	BEER	Dollar	2002	-18%
Coudert and Couharde (2005)	FEER	REER Dollar	2003	-23% -44%
Frankel (2004)	Modified PPP	Dollar	2000	-35%
Goldstein (2004)	Simplified FEER	REER	2003	-15 to -30%
Jeong and Mazier (2003)	FEER	REER Dollar	2000	-33% -60%
Wang (2004)	BEER	REER	2003	Near 0
Wren-Lewis (2004)	Modified BEER	Dollar	2002	20%

Note: 1) The estimates here are not mean to be exhaustive; they should be seen as indicative.
        2) Minus sign implies undervaluation.
Source: Adopted and updated from Coudert and Couharde (2005) and Dunaway and Li (2005).

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